Workshop

Portland Harbor

August 10, 2012

Draft Site Level Recontamination Evaluation Framework

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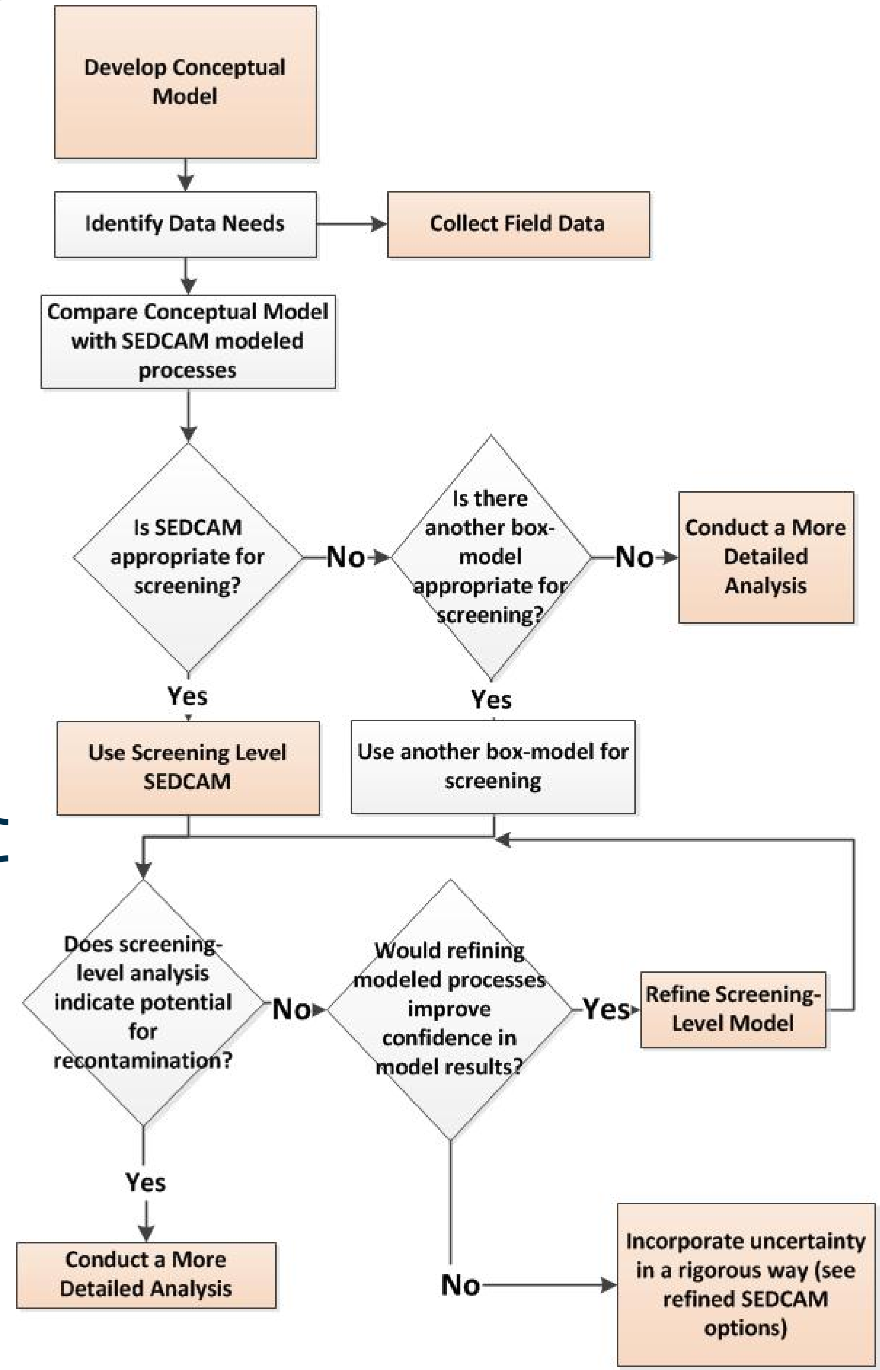
Overall Framework Process

Pre-Feasibility

Feasibility



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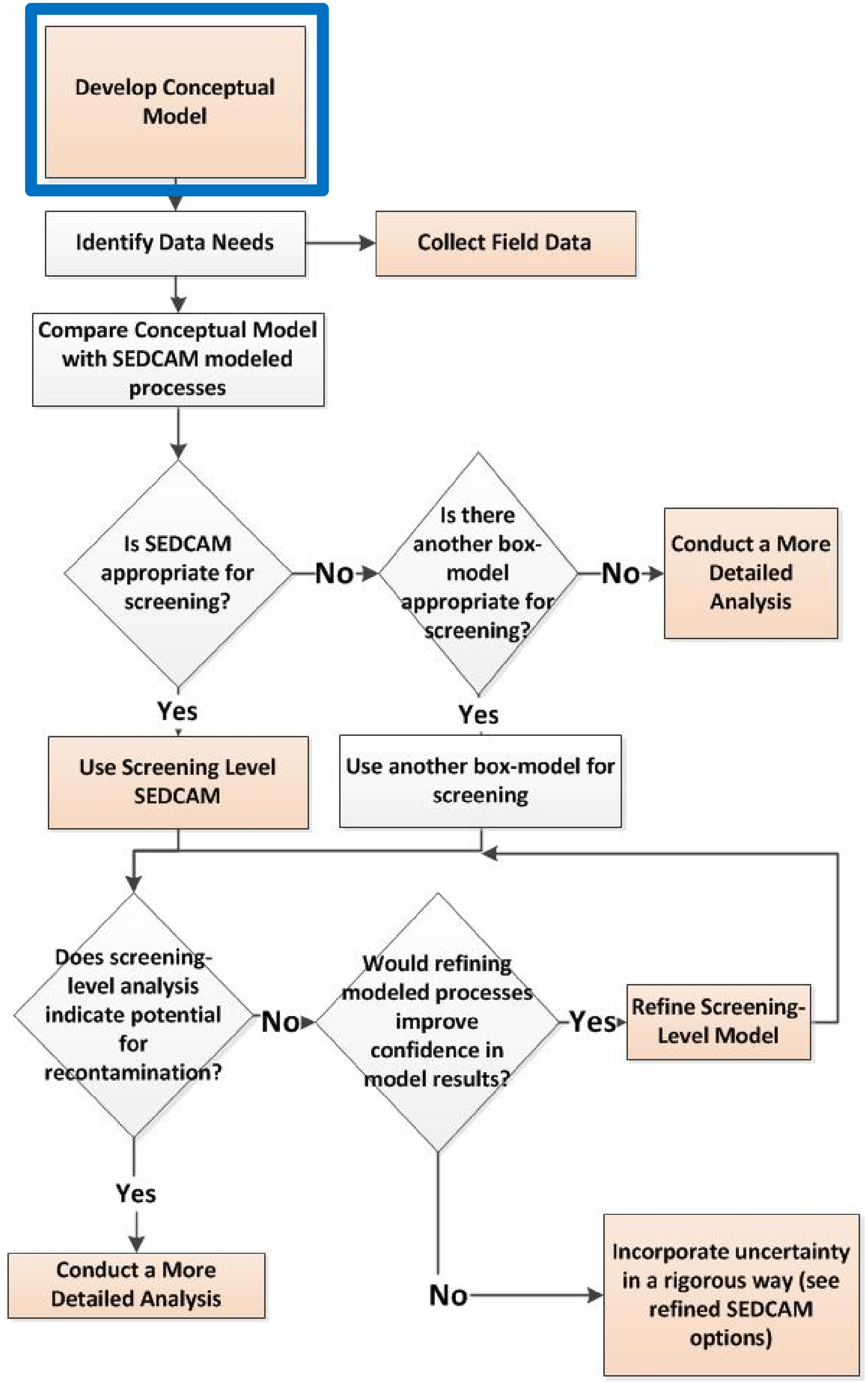
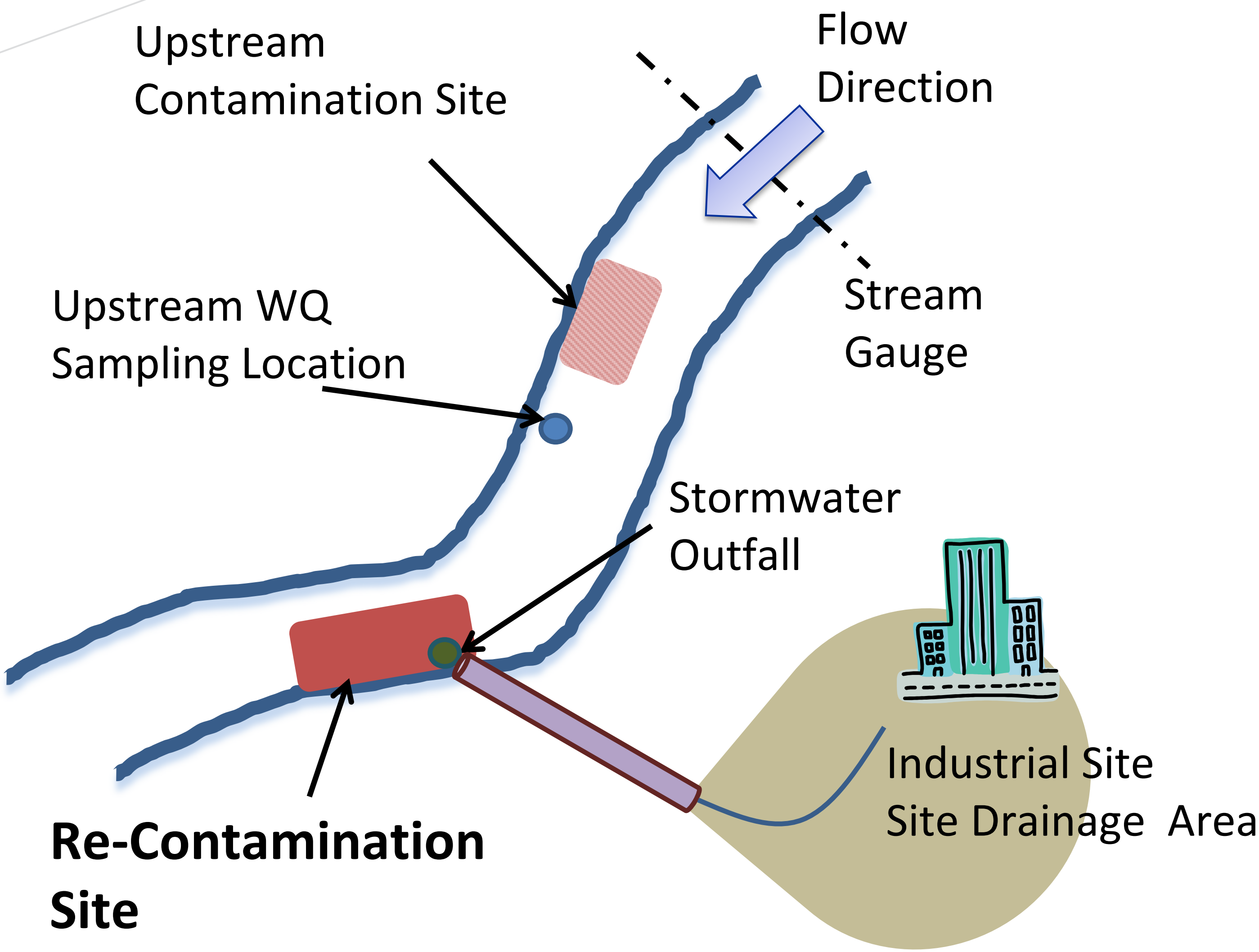
Develop Conceptual Model



Context Conceptual Model



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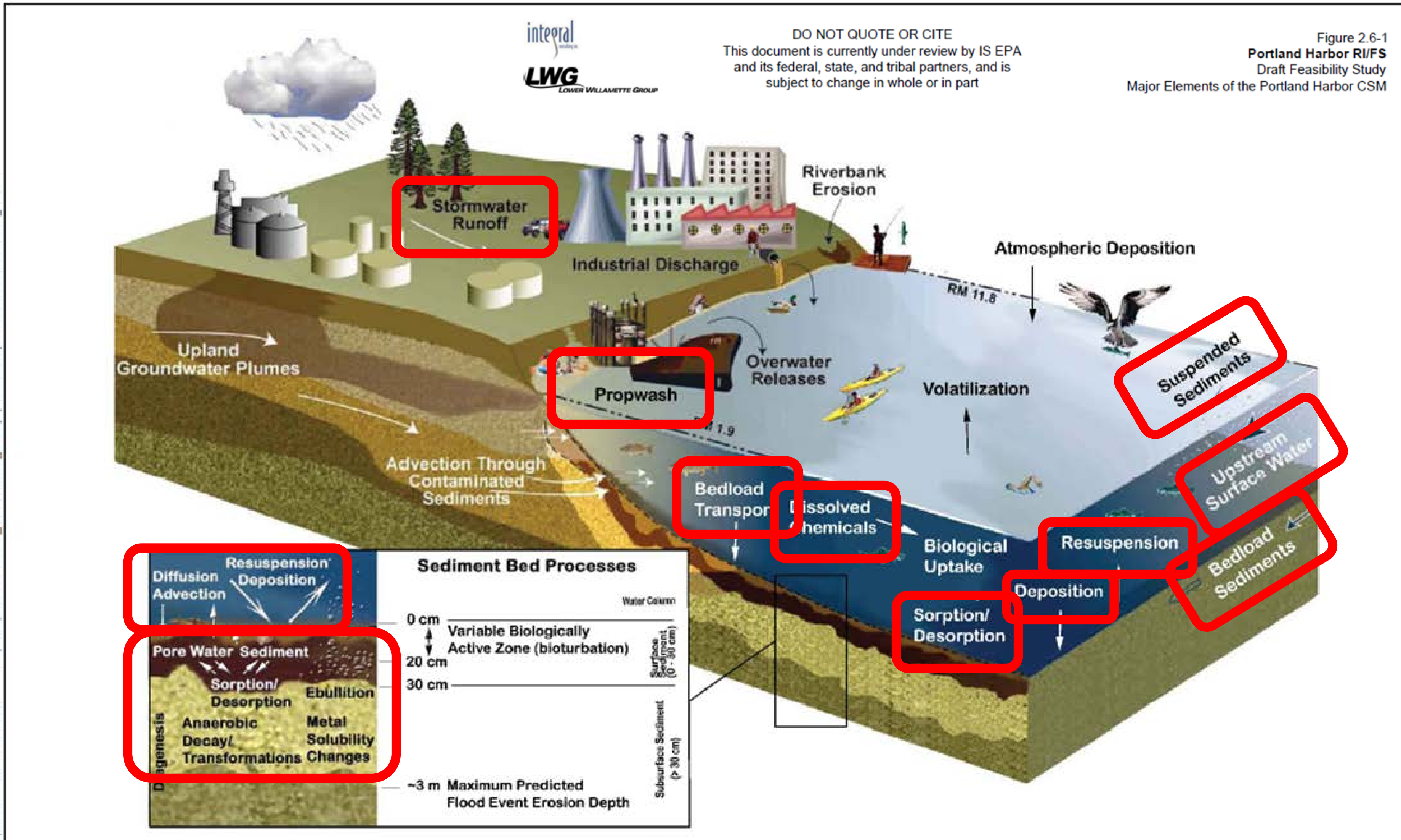
Recontamination Site Conceptual Model



SOURCE: Figure created from PDF provided by Integral Consulting, Inc.

Conceptual Model Objectives

- Identify Important Processes
  - How much do seasonal river flows vary? Is the velocity field expected to be different enough during high flows to change sedimentation rates?
  - How often is re-suspension/scour expected?
  - How much do the recontamination site's characteristics vary within the site?
  - Is deposition of contamination on the sediment bed the primary exposure mechanism?
- Be Quantitative Where Possible
  - Assemble and analyze historical data
  - Estimate relative magnitudes of processes (and estimate uncertainty)
  - Assess environmental variability

Conceptual Model Objectives (continued)

- Identify Data Gaps
  - How comprehensive is historical river flow data?
    - Outfall Runoff data?
    - Outfall WQ data?
    - River WQ data?
  - Can reliable stormwater sedimentation rates be estimated from existing data?
  - Can reliable stormwater pollutant loadings be estimated from existing data?

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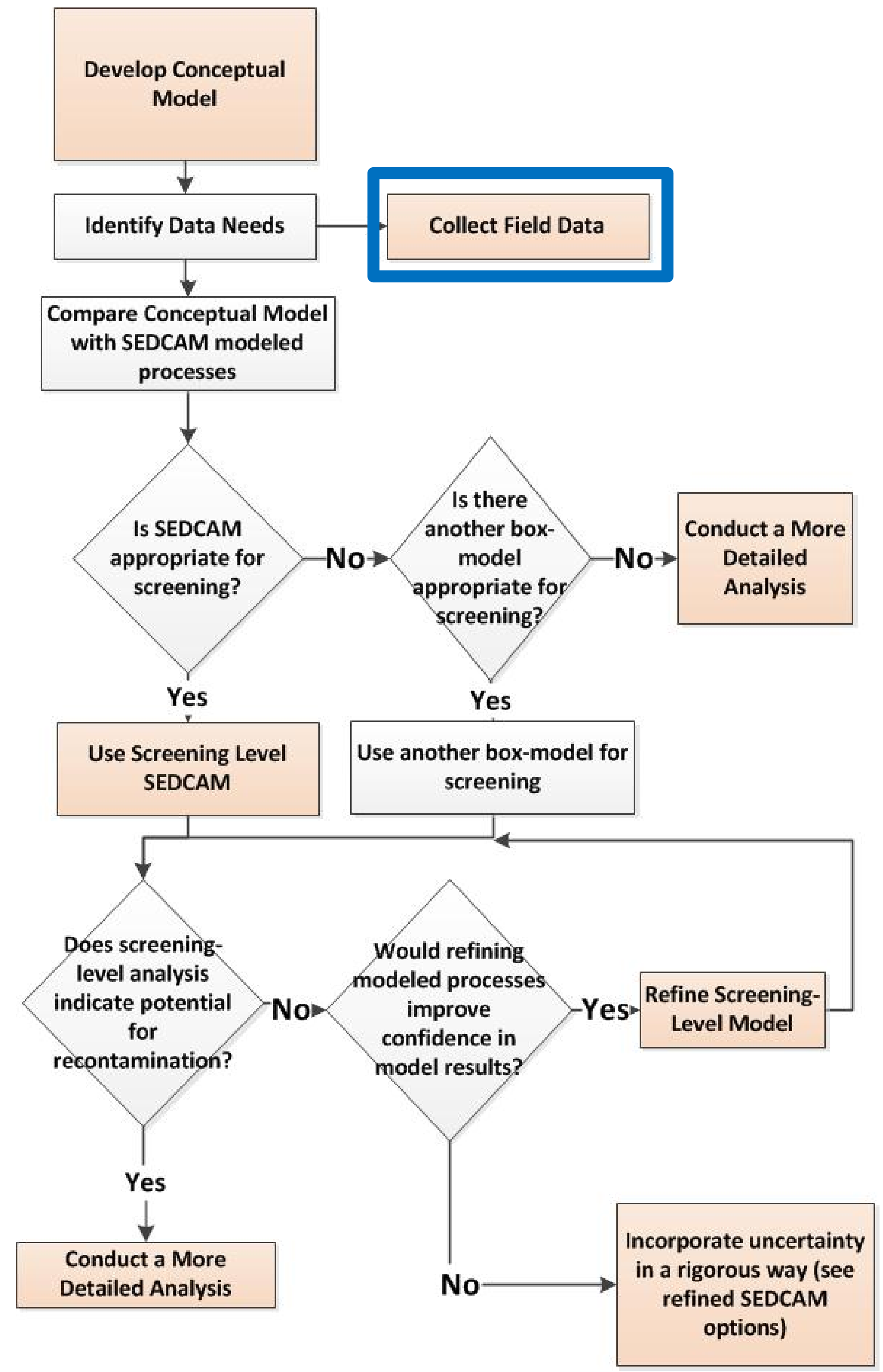
Monitoring Data



Field Data Collection

- Upriver Loading
  - Sediment Traps – generally use available historical data
  - Water Quality Sampling
- Upland Loading
  - Storm Runoff Flows
  - Storm Event Flow Weighted Concentrations or Event Mean Concentration
    - Sediment
    - Constituents of Concern
- At Potential Recontamination Site
  - Sedimentation Rates
    - Sediment traps
    - Cores
    - Bathymetric surveys
  - In-situ Sediment Characteristics

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Field Data Collection (continued)

- Upland Stormwater Monitoring Data
  - Capture seasonal variability
  - Address hydrologic variability
  - Statistically significant sample size
- Specialized Studies
  - Bathymetry
  - Particle size distribution
  - Scour/Deposition area

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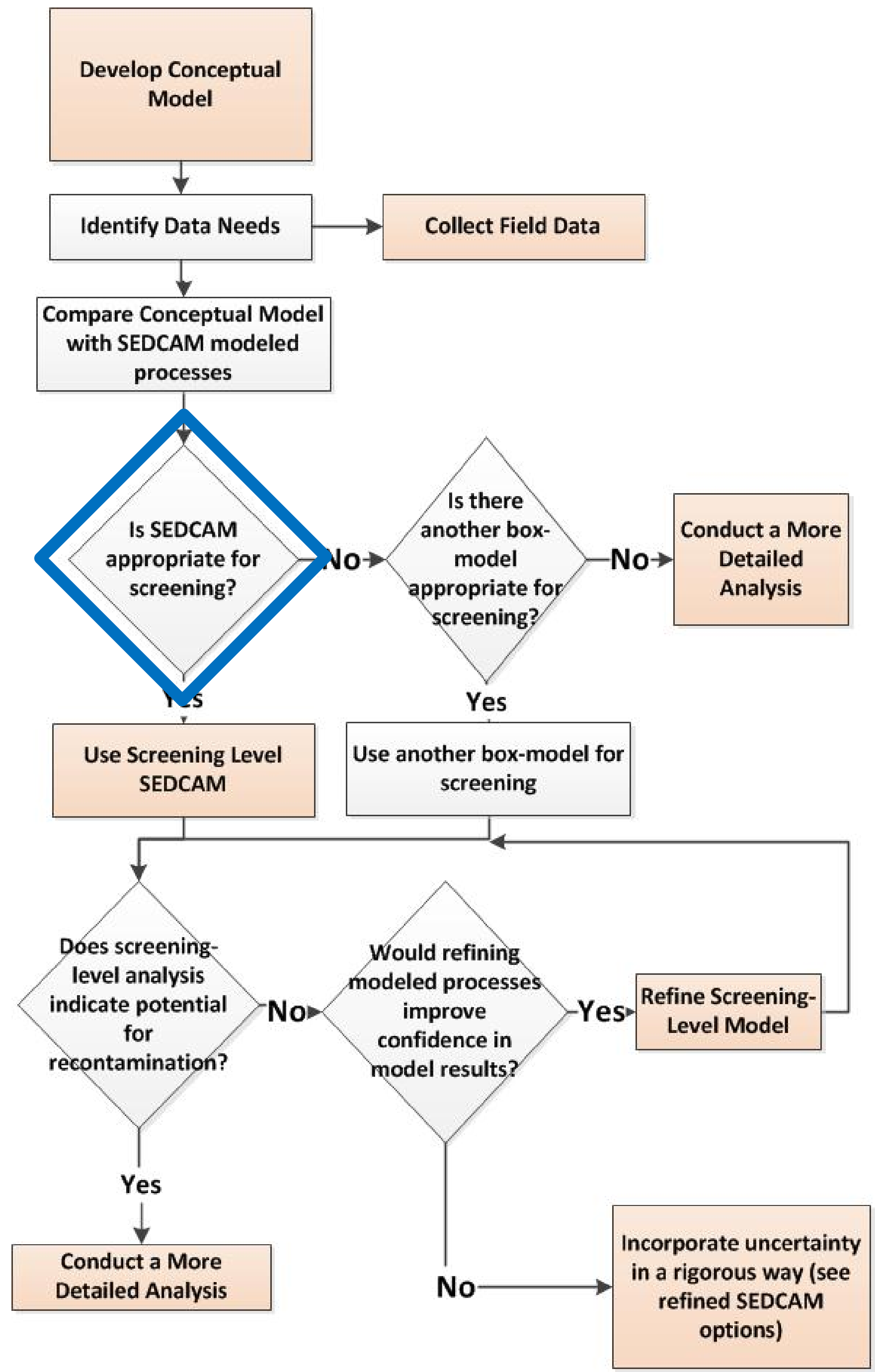
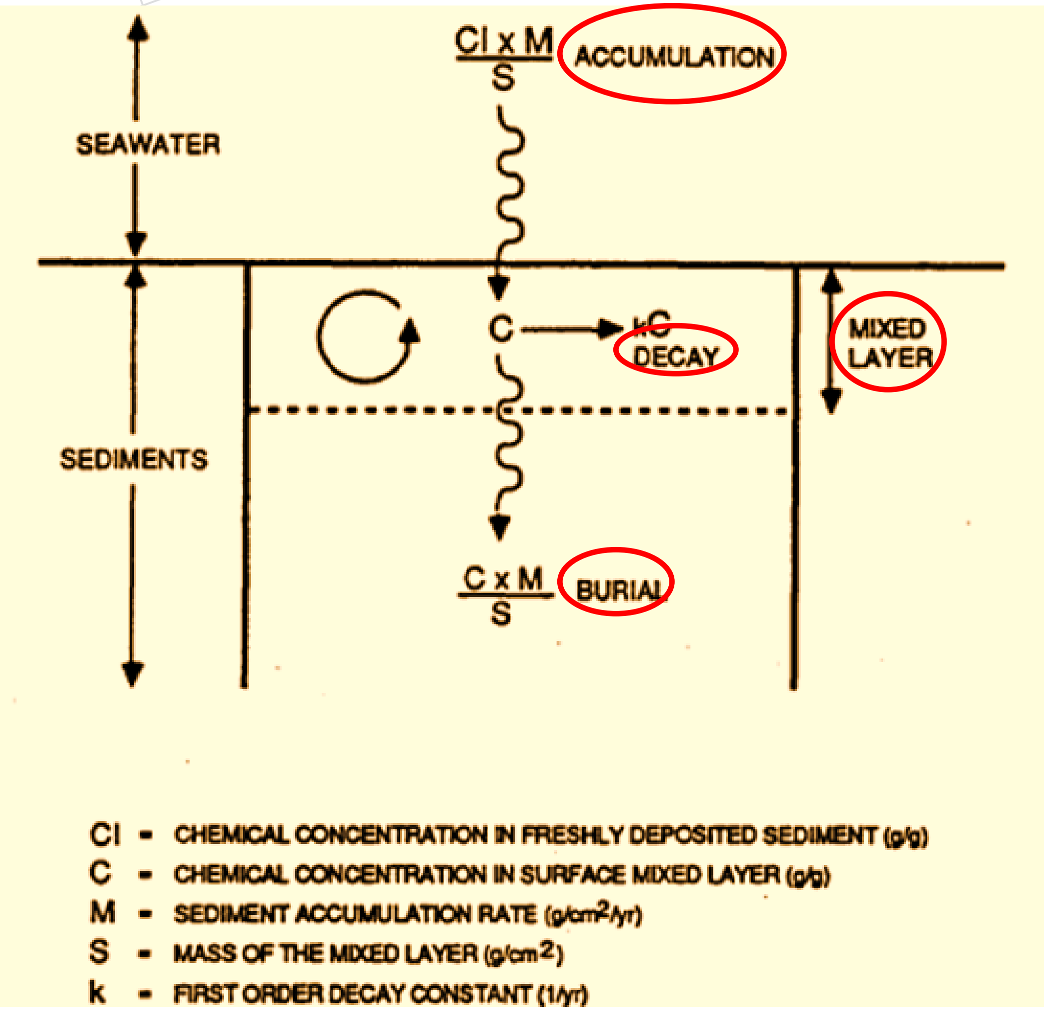
Evaluation of SEDCAM Screening Level Approach



Is SEDCAM Appropriate for Screening-Level?



Steady-state physical system (all terms are constant in time):

- Accumulation (loading) rate of sediment and contaminant
- Mixed layer thickness
- Decay rate to represent diffusion and chemical decay
- Burial rate

"Box-Model" – no accounting for spatial or temporal variability

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Is SEDCAM Appropriate for Screening-Level?

- ✓ Can important physical processes be represented in SEDCAM?

  For example: Re-suspension may be considered important.

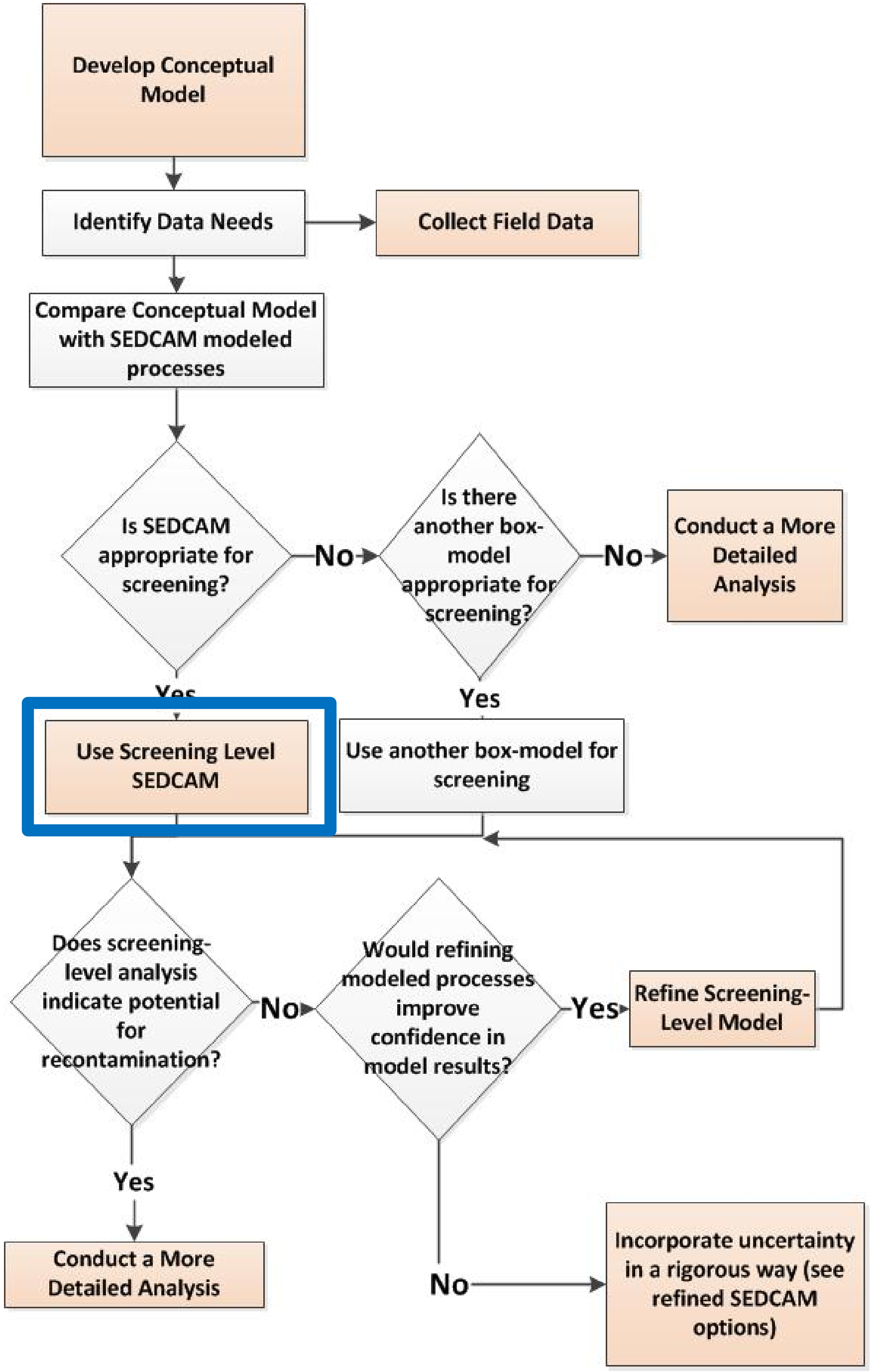
- ✓ Is the steady-state condition either an accurate, or at least a conservative, representation of the recontamination site?

  For example: Recontamination sites that are in open river channels may experience temporal variability that is difficult to capture using SEDCAM

- ✓ Are conditions spatially uniform enough to apply a box-model?

- ✓ Can conservative model inputs be reliably estimated?

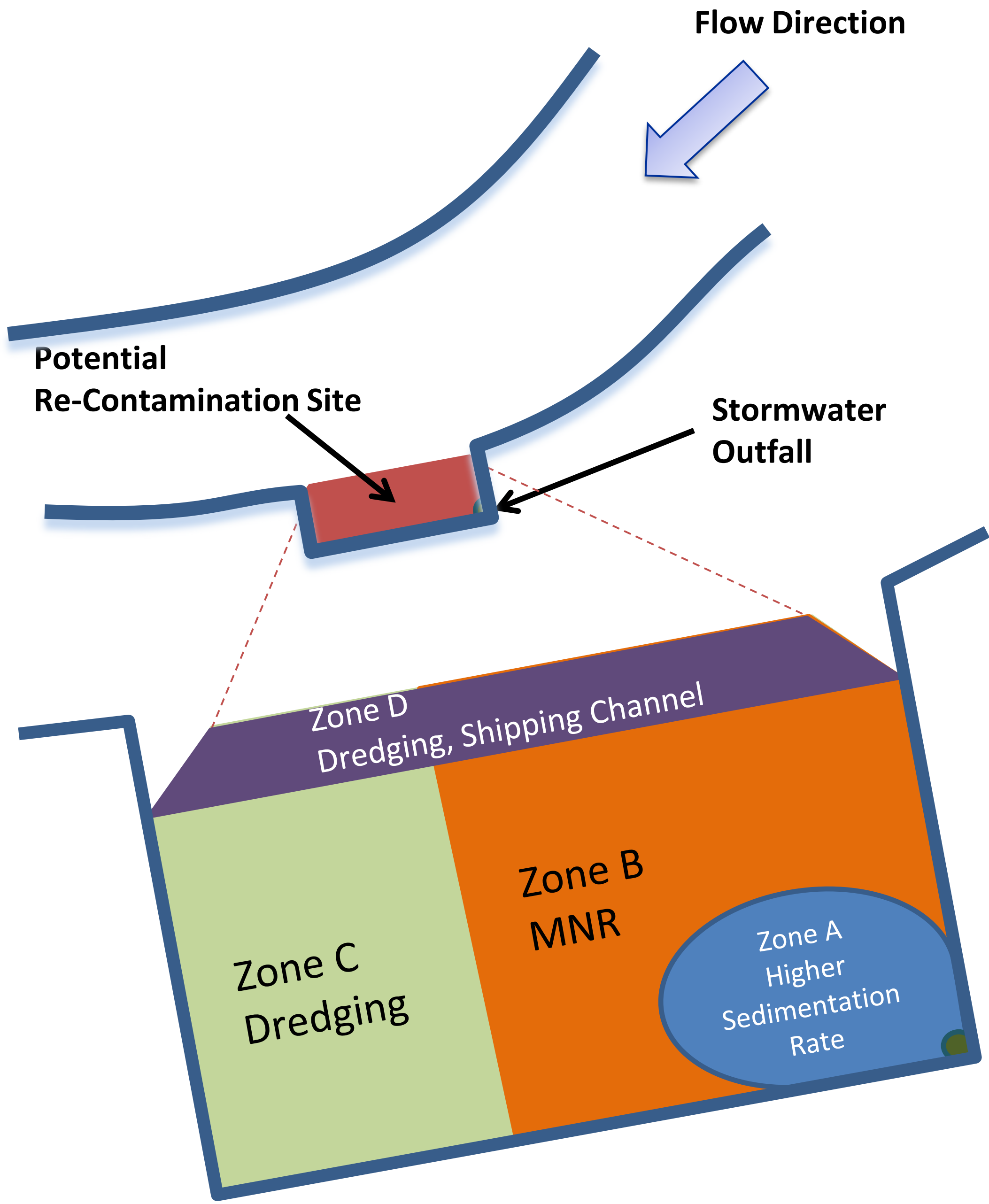
Screening-Level SEDCAM (or other 1-d model)



Define Subareas

Break recontamination site into subareas for model application using:

- Remediation activity
- Sediment properties
- Sedimentation rates/loading



Develop Design Scenarios for SEDCAM

Scenarios are site-specific, but should bracket:

- Estimated ***uncertainty*** in model parameters/inputs
- Estimated hydrologic and environmental ***variability***

Long historical datasets help quantify variability

Comprehensive datasets help quantify uncertainty

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Develop Design Scenarios for SEDCAM (continued)

A Design Scenario should: bracket the most realistically conservative conditions with a safety factor

- Recommend multiple scenarios
- Possible Conservative Scenario:
  - Highest possible expected contaminant loadings
  - Lowest possible expected "clean" sediment loadings
- Example:
  - Apply expected near-field stormwater outfall deposition to entire sub-area
  - If upstream contaminant loadings are low and local stormwater loadings are high, apply dry weather river flow loadings with wet weather stormwater loadings

Develop Design Scenarios for SEDCAM (continued)

- Model Parameters to be estimated for each scenario:
  - Mixed layer thickness/Mass of mixed layer
  - Decay rate
- Inputs to be estimated for each scenario:
  - Sediment loading
  - Contaminant loading

Additional Guidance

Setting Up SEDCAM

- 1 Equation - can be solved in Excel
- *Validation is recommended, if possible*
  - *Use historical data to check that model can qualitatively represent the site*
- Run each scenario
- Perform sensitivity analysis

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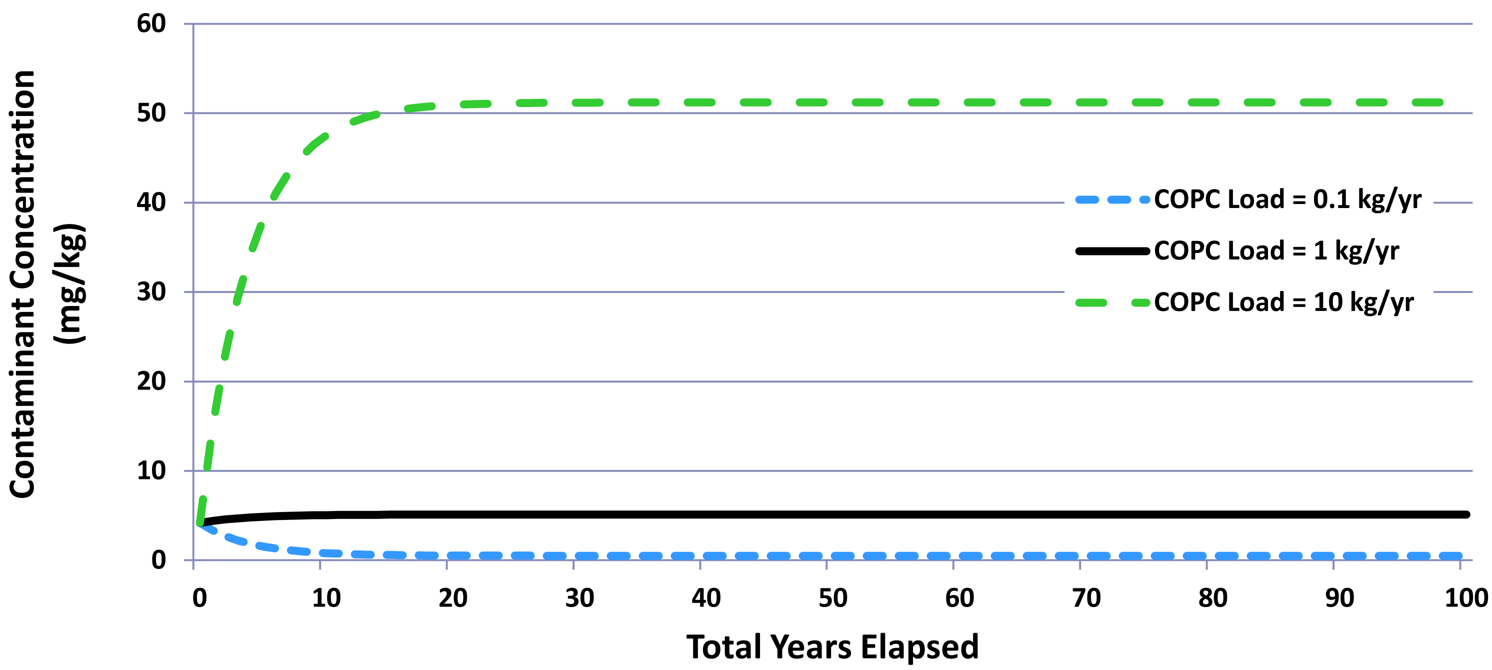
Sensitivity Analysis: Purpose

- Identify sensitive parameters and inputs
- Qualitatively estimate impact of using less conservative values



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Sensitivity Analysis: Methodology

Evaluate impact of model input variations within reasonable range of values

- Mixed depth
  - Increasing and decreasing by **a factor of 2** may be appropriate
- Decay Rate
  - Increasing and decreasing by **1 to 2 orders of magnitude** may be appropriate
- Sedimentation Rate
  - **Factor of 10** may be appropriate, to account for local variations
- Contaminant Loading Rate
  - Should be **determined from range of measurement data – increasing by** 1-2 orders of magnitude may be appropriate (or by **1-2 standard deviations**)
- Sediment Density
  - **Factor of 2** may be appropriate

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Value Ranges in Portland Harbor Studies

	Terminal 4	Gasco	Arkema	LWG
Measured Sedimentation Rates	0 – 4 cm/yr	NA	0 – 30 cm/yr	Net erosion to over 10 cm/yr
Estimated Mixed Layer Thickness	15-25 cm	Modeled mixing in top 30 cm	15 cm	Modeled mixing in top 30 cm
Sediment Density	1.53 g/cc	Used LWG	0.92 g/cc (average)	0.7 – 1.2 g/cc (average)
Contaminant Loadings	Different COI for each site			
Decay Rate	None used	NA	NA	NA

NA – data not available or not applicable

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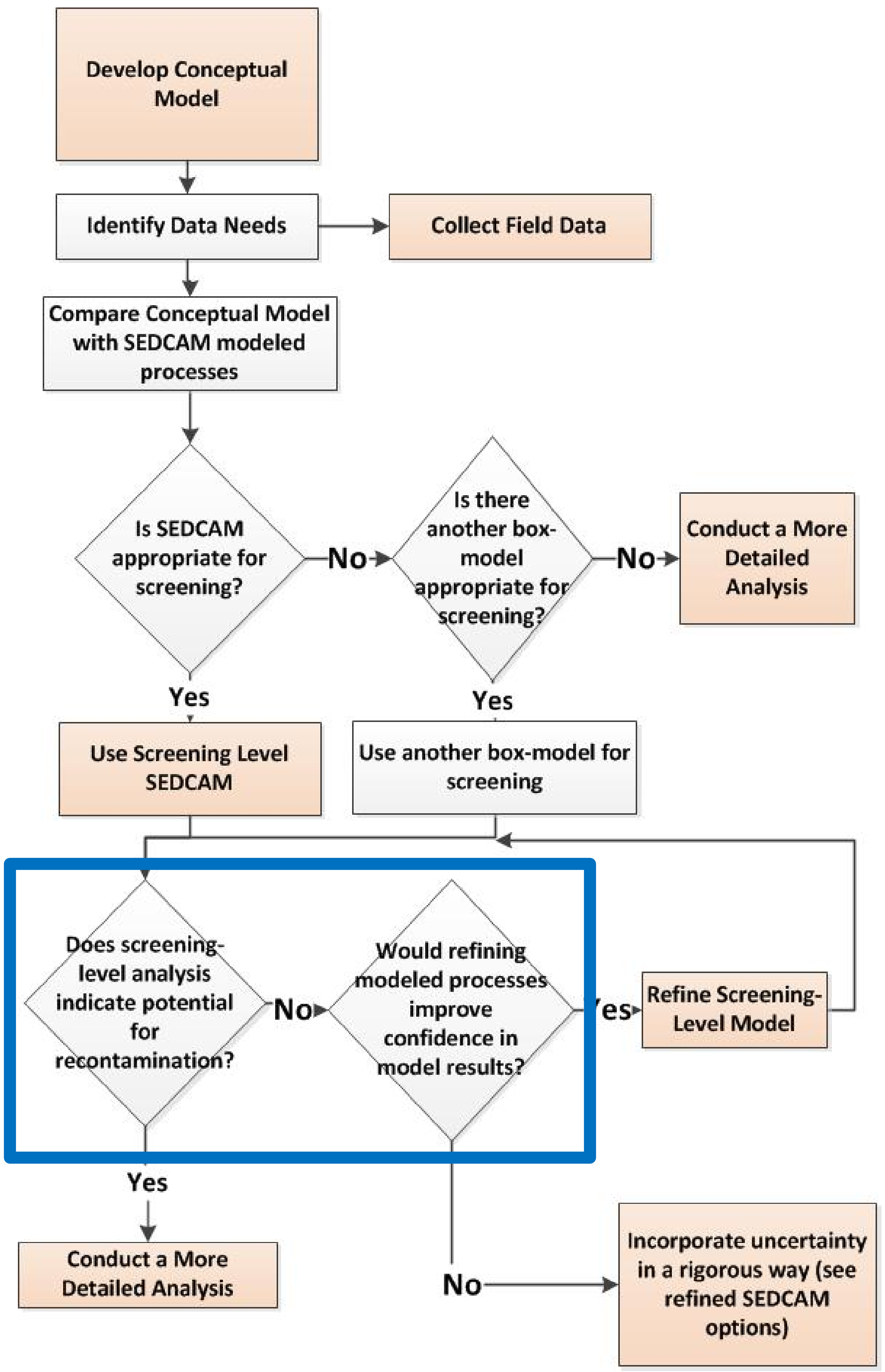
Evaluate screening-level results



What is the risk of recontamination?

- Identify concentration threshold for "recontamination"
- Is recontamination predicted by conservative scenarios?
- Does model sensitivity indicate potential recontamination?

If YES, then a more <u>detailed analysis</u> is recommended

If NO, then one or more <u>simplified refinements</u> are recommended to verify confidence in the model

Refined Screening-Level Analysis

Considerations in Refining Analysis:

- ✓ Uncertainty: Would additional data improve confidence in model parameters/inputs?
- ✓ Accuracy: Would further dividing modeled subareas increase model accuracy?
- ✓ Uncertainty bullet. Do conservative inputs sufficiently represent uncertainty and risk?
- ✓ Variability: If hydrologic variability is significant, would using time-varying model inputs produce a more accurate scenario?

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Potential SEDCAM Refinements

Refinement	Advantage
Use time-varied loading	Represent hydrologic variability
Allow mixed layer thickness to change in time	Improve accuracy for sediment capping areas
Run a Monte Carlo suite of scenarios	Improve variability representation
Refine model inputs with additional field data	Reduce model uncertainty
Refine subareas into smaller sections	Increase accuracy of parameters/inputs
Use CORMIX to quantify: 1) Near-field stormwater outfall deposition zones 2) Sedimentation rates in near-field	Refine “worst-case” loading estimates

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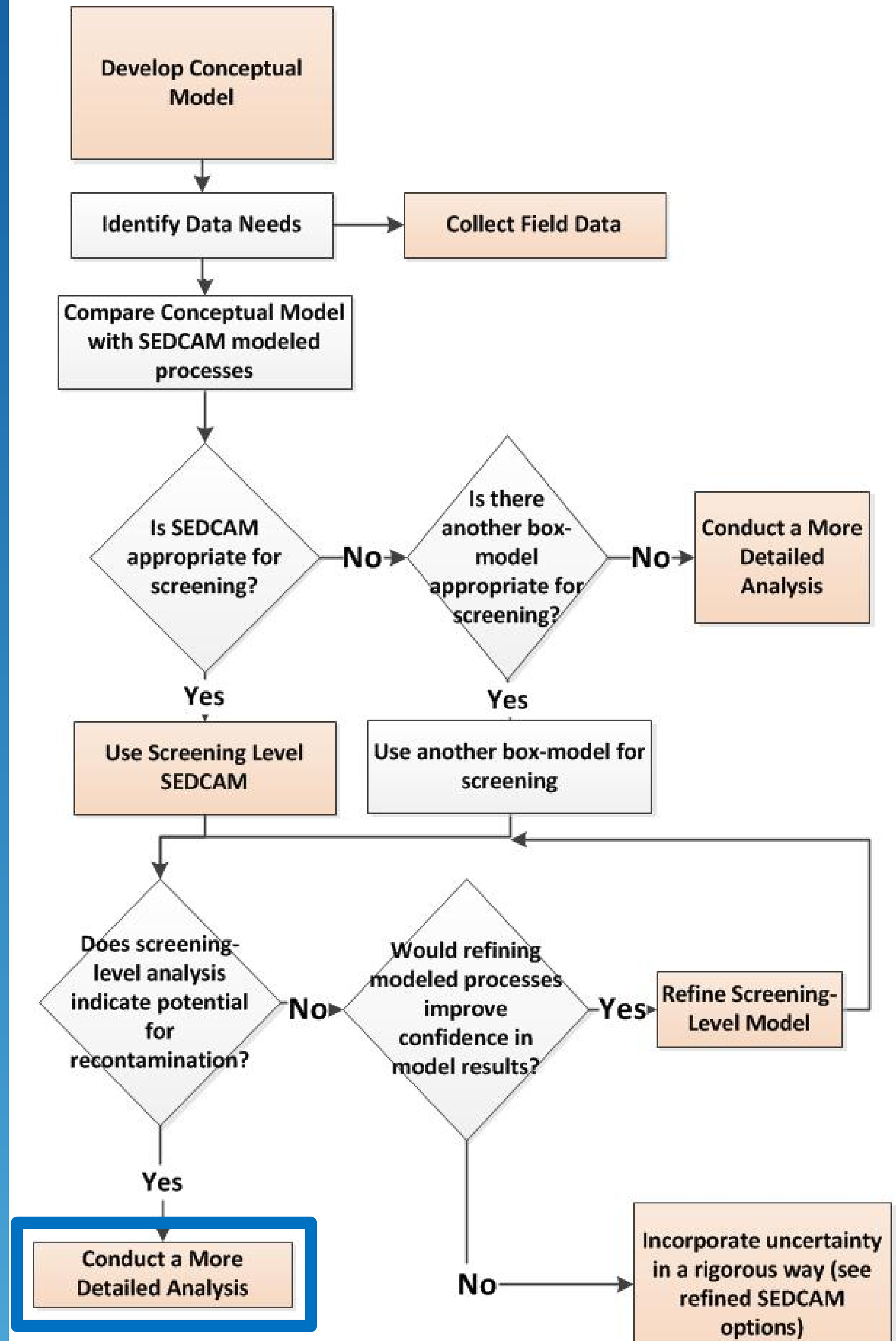
More detailed analysis



Available Tools

	Box Models and 1D Models	2D-3D
Description	Models simplify sediment to a single mixed layer. SEDCAM: - represents sediment inputs with a single input term (sediment loading) and a single output term (burial). Inputs can be calculated from field data or from hydrodynamic/hydraulic sediment transport models.	Models represent sediment with several vertical layers and several horizontal cells. Represents chemical transport, including biological and chemical processes.
Processes included	- Sedimentation - Contaminant loading - Chemical decay - Advection/Diffusion May also include: - Erosion/resuspension - Chemical partitioning - Sorption	May include: - Hydraulics, particle settling velocities and resuspension - Chemical and sediment transport in the water column - Bioturbation - Diffusion - Sorption
Advantages	- Simple to use - Can be modified to incorporate uncertainty and variability (see Refined versions of SEDCAM)	- Can represent horizontal and vertical variations in properties - Incorporates temporal changes in model inputs - May more accurately represent diffusion, chemical/biological decay and advection

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Choosing The Appropriate Tools

- Important Processes: Return to Conceptual Model
- Questions to Consider: See checklist

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Checklist

- Do the physics and chemistry represented in the model match the conceptual model?
- Is important accuracy sacrificed for simplicity?
  - Or conversely, where unavoidable unknowns exist, is the model overly complicated? This can also increase model error.
- Can the model adequately represent both:
  - Large-scale processes such as watershed loading
  - Smaller-scale processes such as local sedimentation rate variations

Checklist (continued)

- Is there sufficient data to accurately represent all the physics in the model? If not, can that data be obtained?
- Has the model been used before for a recontamination or long-term sediment treatment evaluation?
- Can the model represent changes in site features over time?

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